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Third Quarter: Modern History.

April: The French Revolution. Selections from Wordsworth. Dickens' *Tale of Two Cities*, or Goldsmith's *Vicar of Wakefield.*

May: Epoch of Reform. Selections from Shelley.

June: Anglo-Saxon Expansion. Tennyson's *Princess.*

Fourth Year, American History, Economics, Civics

First Quarter: American History.

October: Period of Discovery and Colonial History. Lowell's *Columbus* and *A Glance behind the Curtain.* Shakespeare's *Hamlet.*

November: Colonial History. Whittier's *Snow Bound.* Shakespeare's *Hamlet.* Cooper's *Last of the Mohicans.*

December: The Revolution. Burke's *Conciliation with America.* Shakespeare's *Hamlet.*

Second Quarter: American History.

January: Critical Period. Emerson's *Essays.*

February: Westward Movement. Ruskin's *Of King's Treasuries.*

March: Slavery Question. Selections from Lowell's Poems.

Third Quarter: American History.

April: Industrial Development. Tennyson's *Locksley Hall.* George Eliot's *Silas Marner.*

May: Industrial Development. Selections from Robert Browning's Poems.

June: Industrial Development. Matthew Arnold's *Sohrab and Rustum, Self-Dependence and Progress.*

Professional School

First Year

It is intended to make this work a practical study of the subject-matter and methods of the elementary school. It will be necessary to consider first the fundamental principles underlying the teaching of history, and then the outline of the course. After this has been done, the students will investigate the subjects useful for lessons with the little children. This will necessitate a study of Primitive Culture. The students will also begin the related handwork of the industrial arts, especially pottery and textiles.

In literature the work will include typical stories of different nations and periods of history, principles of presentation of these stories to children, relation of literature to history and art, observation of model lessons, and writing of stories.

Second Year

In this year we shall follow the chronological order of history rather than the order of the subjects as taught in the grades. The aim of the work will be to consider methods of historic study, and to give a fuller knowledge of the subject-matter. Having learned in the first year what they need in order to teach history, the students will study with especial purpose. They will be expected to plan work for teaching more independently than before and to give more lessons. The course in the High School may also be considered by those who desire to prepare to teach in secondary schools. The literature for this year will be correlated with history as in the High School, and especial attention will be given to oral reading and dramatic representation.

Applied Algebra

George W. Myers

ACADEMIC DEPARTMENT: The work for November will consist mainly of the geometrical representation of equations. The equations studied last month were brief expressions of simple laws of physics and mechanics. One ($v=gt$) is a statement of the law which connects the velocity (v) of a falling body with the time (t) during which the body has fallen. Another ($f=mx$) is the law which connects the force with the mass and acceleration of a body which moves under the action of a varying force. In the first case v and t and in the second, f and x are changing continuously, while $g(=32.16\text{ft.})$ and $m(=\text{mass moved})$ remain fixed. And so it is with every algebraic equation. In the equation $y=x$, if $x=1$, y must equal 1; if $x=2$, $y=2$; if $x=2\frac{1}{2}$, $y=2\frac{1}{2}$; if $x=10$, $y=10$; if $x=a$, $y=a$, and so on indefinitely. Any value between those used here might be put equal to x, whereupon y would be equal to the same value. Hence, we see that there are an indefinitely great number of pairs of values for x and y. The equation merely says that whatever value x may have, y must have the same value.

Again, in the equation $y=3x+4$ we have merely an abbreviated statement of the law that whatever x may be equal to, y must equal 4 units more than its triple. It is clear, then, that the numbers of arithmetic (in the last equation the 3 and 4) differ from the numbers of algebra (the x and y) in that the arithmetical numbers have a fixed value, while the algebraic numbers have variable values. Numbers like the x and y, or the v and t, or the f and x, which in a given equation may vary, are called *Variables.* Numbers which always have the same values are called constants.

Principle—An algebraic equation is a brief statement of the law in accordance with which two or more variables are supposed to change.

NOTE.—It may be that in a given case only one pair, or a limited number of pairs, of the values of x and y are wanted. But we are seeking to make clear what the equation means and all it means. This can be done only by making it very plain that both x and y may have an indefinitely great number of values in one and the same equation.

To make the true meaning of the equation very clear will be the purpose of this month's work.

Axiom 1—If the same quantity, or equal quantities, be added to, or substracted from, equal quantities, the results will be equal.

Illustration—If $x=y$, then $x+a=y+a$; or if $x=y$ and $a=c$, then $x+a=y+b$.

Axiom 2—If equal quantities be multiplied, or divided, by the same quantity, or by equal quantities, the results will be equal.

Illustration—If $x=y$ and $a=b$, then $ax=by$; or if $ax=by$ and $a=b$, then $x=y$.

An algebraic expression is any symbol, or symbols, of quantity, or any number of such symbols connected or affected by symbols of operation. An algebraic expression, of course, represents a number.

Symbols of operation are the signs of addition (+), subtraction (−), multiplication (×) or the period (·), division (÷, / or —), involution (the exponent), and of evolution (the radical sign, √.,).

The parts of an algebraic expression connected by the plus and minus signs are called the terms. Terms are similar when they contain the same literal factors. Otherwise, they are dissimilar.

Any two number-symbols, which represent the same or equal numbers, when written one to the left and the other to the right of the symbol of equality (=), form an equation. The two number-symbols are called the members or sides of the equation, and they are distinguished as the right member (or side) and the left member (or side).

An equation is said to be satisfied, or verified, when by replacing one or more of its literal quantities by arithmetical numbers the two sides become identical, or the equation is reduced to an identity.

To solve an equation for any particular quantity may mean either of two things, viz.:

1. To find the arithmetical number

which substituted for the quantity in question will satisfy the equation; or,

2. To express the quantity in question in terms of the other quantities in the equation.

Problems

Plot the graphs of the equations below on cross-ruled paper. Use the side of one or more of the squares as the unit for plotting.

A graduated scale, a right line pen, a fine steel writing pen, some black, red, and blue or green India ink, and an irregular curve will be needed.

Direction: Use heavy black lines for the axes, blue or green lines for the graphs and dotted red lines for the x- and y-distances of plotted points, which latter should be inclosed in small red circles.

REMARK.—In plotting graphs it is usually, though not always, advantageous first to solve the equation for y, then to assume any desired values for x and compute the corresponding values of y.

Equations of Type I: Form $F=\mu R$ (law of friction), or $v=gt$, or $v=gt+v_0$ (law of falling bodies); Type form is $y=mx+b$; (a) $y=2x$; (b) $y=5x$; (c) $y=-4x$; (d) $2y=3x$; (e) $-2y=3x$; (f) $2y-3x+4x-y=0$; (g) $2x+y-3=5$; (h) $\frac{x+y}{3}+2x-3y+1=3$; (i) $y/x=5$; (j) $x/y=-2$; (k) $\frac{6x-3y}{2}-\frac{4x-5y}{3}=\frac{5}{6}$.

Equations of Type II: (A) $v^2=2gh$ (flow of water from orifices) and $t^2=\frac{2}{9}.S$ (falling bodies). Define and teach exponent, square root and radical sign. (a) $y^2=x$; (b) $3v^2=12x+3$; (c) $y^2=x+3$; (d) $\frac{y^2}{2}+x-2=1$; (e) $y^2=-7x$. Type form is $y^2=ax+b$.

Equations of Type II: (B) $f=(\frac{1}{2r})\,v^2$ (centrifugal force) $S=\frac{1}{2}ft.^2$ (accelerating forces) or $S=g_2t^2-S_0$ (falling bodies); (a) $y=x^2$; (b) $y=3x^2-2$; (c) $y=2x^2+5$; (d) $2y=6x^2-4$; (e) $y=6x^2+3x+4$.

Type form is $y=ax^2+bx+c$.

Other practical equations of this type are the following:

$P=100C^2$ is the formula for the safe working load of manila ropes (hemp ropes and tarred hemp ropes).

$P=600C^2$ is for iron wire rope of 7 strands (19 wires to the strand).

$P=1000C^2$ is for steel wire rope of 7 strands (19 wires to the strand).

$P=12000d^2$ is for open link chains, and

$P=18000d^2$ is for stud link chains where P is the safe working load in pounds, C the circumference of the rope in inches, and d is the diameter of the link in inches.

Plot these equations and read off from your diagrams the dimensions of ropes and chains needed to bear various given loads.

Equations of Type III: Form $X^2+Y^2=R^2$. (Relation of a force to its rectangular components. Fundamental equation of mechanics.) (a) $x^2+y^2=4$; (b) $3x^2+3y^2=27$; (c) $x^2/2+y^2/2=2$; (d) $3x^2-2y^2+4x^2+9y^2=28$.

Equations of Type IV: Form $Ax^2+By^2=C$. (Planetary orbits; Law of Kepler.) (a) $x^2+9y^2=9$; (b) $4x^2+16y^2=64$; (c) $4x^2+25y^2=100$; (d) $x^2+12y^2=12$.

Equations of Type V: $Ax^2-By^2=C$. (Cometary orbits; Law of expansion of gases.) (a) $x^2-y^2=4$; (b) $3x^2-4y^2=12$; (c) $-4x^2+50y^2=200$; (d) $5x^2-3y^2=15$; (e) $xy=12$.

Simultaneous equations are such as are satisfied by the same pair, or pairs, of values of the variables.

Plot on the same axes the following pairs of equations, draw in full red lines the x- and y-distances of the crossing points of the graphs and scale off their lengths.

(a) $\begin{cases} y-x=2; \\ x^2+y^2=25; \end{cases}$ (b) $\begin{cases} x+y=4; \\ x^2+y^2=25; \end{cases}$

(c) $\begin{cases} y^2=x; \\ 5y-3x=-2; \end{cases}$ (d) $\begin{cases} 16x^2+4y^2=64; \\ x^2+y^2=9; \end{cases}$

(e) $\begin{cases} 4x^2+16y^2=64; \\ x^2+y^2=9; \end{cases}$ (f) $\begin{cases} y^2=x; \\ x^2+y^2=20; \end{cases}$

(g) $\begin{cases} 4x^2-16y^2=64; \\ x^2+y^2=25; \end{cases}$ (h) $\begin{cases} 9x^2-16y^2=144; \\ 9x^2+25y^2=225; \end{cases}$

What kind of graphs were found to represent equations of Type I? of Type II (A)? of Type II (B)? of Type III? of Type IV? of Type V?

The absolute term of an equation is the term which does not contain a variable. (How does an alteration of the absolute term of an equation affect the graph? An alteration of the coefficients of the variables? Of the exponents?)

It will now appear that a line represents an equation when the x- and y- distances of every point in the line satisfy the equation and when no other points do have distances which satisfy it. For this reason a graph is sometimes termed the *Locus* of the equation.

Here develop the algebraic methods of solving simultaneous simple equations and compare results with those furnished by the foregoing geometrical methods. As a preliminary means to this, the use of the parenthesis, the fundamental operations, factoring and fractions must be learned.

Pedagogic School

Seventh and Eighth Grade Mathematics—Study of Force.—Continued. A fuller development of the method of studying force than could be given last month will be worked out here.

A force is completely known when we know (a) its magnitude or intensity, (b) its direction or sense, and (c) its point of application.

Statics is the Theory of Equilibrium. When three forces, acting upon a free point, just balance, or produce no movement of the point, they are said to be in equilibrium. The point is said to be at rest.

When three such forces are in equilibrium their magnitude and direction may be represented by the three sides of a triangle (triangle of forces). The triangle is, therefore, fundamental to Statics.

But since any one of these three forces just balances the joint effect of the other two, if one of the forces were removed the point would move under the joint action of the other two precisely as though it were acted upon by a single force equal in intensity and opposite in direction to the force removed. Hence, the Theory of Motion (Dynamics) is also based upon the triangle.

If any number of forces act upon the same point at the same instant (concurring forces), their combined effect (their resultant), may be found by the successive use of the principle of the parallelogram of forces as shown in the cut. The successive segments of the broken line $OP_2R_2R_2R_3R_4$, etc., represent in magnitude and direction the forces whose combined effect will produce equilibrium (Polygon of forces).

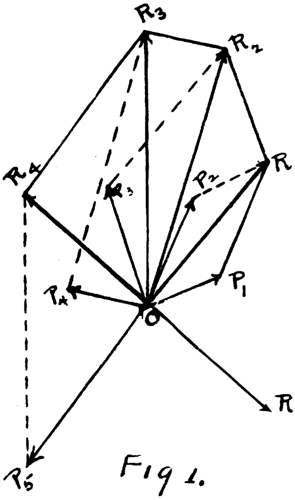


Fig 1.

Study here rectilinear figures concretely, speaking of the sides and angles of the figures as the magnitudes and directions of forces.

A more general method of studying forces is that suggested by this figure:

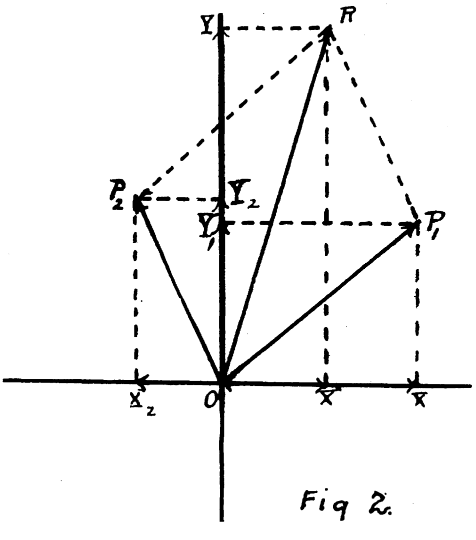


Fig 2.

It is at the same time simpler than the former, as it makes the right triangle fundamental. Explain the method and make a concrete study of the right triangle.

The parallelogram is inserted in the figure to show the agreement of this and the former method.

The third figure shows that this method

applies to any number of forces. Explain how. Define Resolution of forces, Composition of forces, and Transmissibility of forces.

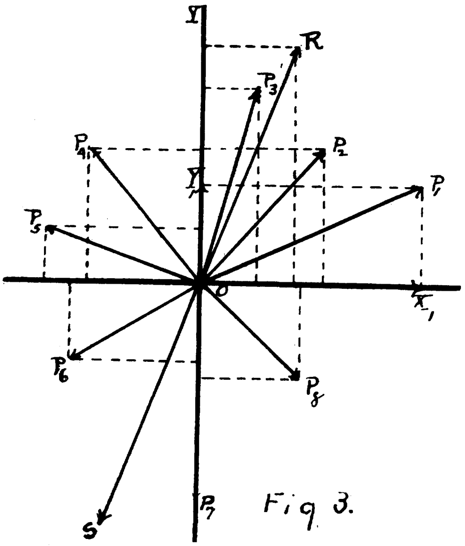


Fig. 3.

In connection with the last figure define Conspiring forces, and explain and discuss the algebra of compounding them.

With the aid of the fourth cut show the difference between the problem of treating forces acting upon a point and forces acting upon a body.

Obviously the two forces acting at the points where these letters stand tend not only to move the body forward, but they tend to turn it, to rotate it as well. The single force, the resultant, acting at *M* does not in this case produce the same effect as do *P* and *Q* acting jointly. Under the action of *P* and *Q* the motion of the body would be composite, consisting of a translation such as *R* would produce, and at the same time of a turning motion.

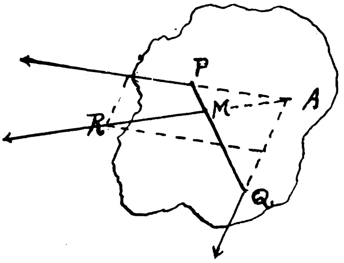


Fig. 4

When two oppositely equal parallel forces act as shown in this figure the resulting motion is only a rotation. Such a pair of forces (*v FF*, Fig. 5) is called a *couple.* The tendency of a force to turn a body about a point is called the *Moment* of the force with respect to the point, and it is measured by the product of the force by the perpendicular distance from the point to the line of action (the line along which the force acts) of the force (*a P* of Fig. 5). This Moment is taken as positive when the tendency is to turn the body upward and to the left, and negative in the opposite case. The Moment of the couple is either force (*F*) multiplied by the shortest distance between the lines of action of the two forces (2 *a*).

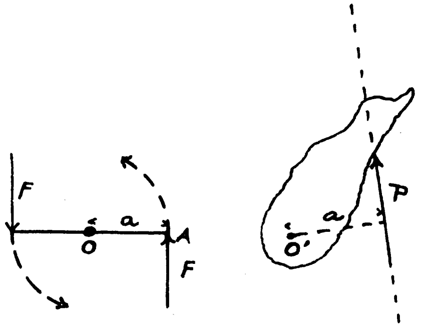


Fig. 5.

Here bring out the algebra and geometry of moments. The moment is represented geometrically by a line drawn perpendicular to the plane of the turning through the point (*o* or *o'*), about which the turning is considered, and containing as many units of length as there are units in the moment.

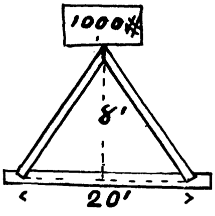
The problem of finding the center of gravity of geometrical forms is interesting and important. The significance of the center of gravity can be best understood by making a preliminary experimental study of a system of parallel forces acting upon a body, by the aid of an apparatus such as is shown in the cut for parallel forces given last month. By its help the resultant may be directly measured, the tendency to turn demonstrated, and the point of application of the resultant found.

It will be readily comprehended that the weight of a heavy body results from such a system of parallel forces, being merely the attraction of the earth for each particle of the body toward the earth's center of gravity, which is so far away that we may regard the elementary forces as parallel. To find the center of gravity is merely to find the balancing point of this set of forces.

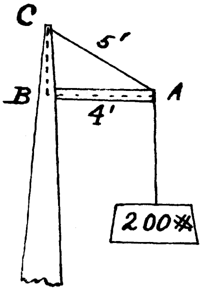
Here take up the geometry of finding the center of gravity of various geometrical figures.

The tendency of a tree or tall structure to fall under the force of the wind will furnish a practical application. What resists or overcomes this tendency (fiber stress)? Numerous applications will suggest themselves.

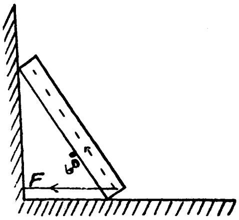
Exercises.



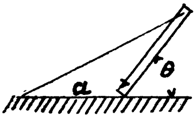
1. Find stress in rafters.



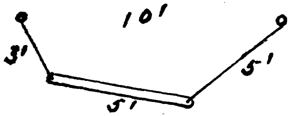
2. Find stress on *A B* and on *A C*.



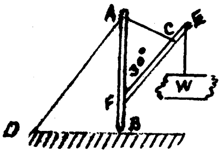
3. The beam weighs 150 pounds. It leans against a smooth wall, and is prevented from sliding by the string or by the force of friction, *F*. Find *F*, or the tension in the string.



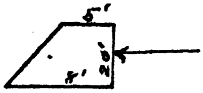
4. Weight of beam = *W*; length, *l*. String or guy, attached at distance *b* from bottom end, and at distance *a* to the left of the lower end. Find tension in string. Use particular values first.



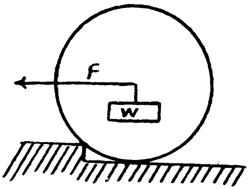
5. Weight of beam = 100 pounds. Find the tension in the strings, also the angles the strings make with the vertical.



6. Boom, *F E* = 30′; *A B* = 40′; *C E* = 7′; *B F* = 5′ and *W* = 1000 pounds. Find stress in *A D*, also in *A C*.



7. Fourteen cubic feet of masonry weigh one ton. Find the force at the middle point that will overturn the wall.



8. Radius of wheel = *r*. Find *F* required to pull it over an obstruction of height *h*. Use particular values first.